REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
27-04-2018	FINAL	

4. TITLE AND SUBTITLE

Air Power's Missed Opportunity: The German Transportation System

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)

Maritime Advanced Warfighting School
Naval War College
686 Cushing Road

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Distribution Statement A: Approved for public release; Distribution is unlimited.
Reference: DOD Directive 5230.24

13. SUPPLEMENTARY NOTES A paper submitted to the Naval War College faculty in partial satisfaction of the requirements of the Joint Military Operations Department. The contents of this paper reflect my own personal views and are not necessarily endorsed by the NWC or the Department of the Navy.

14. ABSTRACT

U.S. and Allied bombing of Germany during World War II affords an invaluable case study in target systems analysis. An examination of the German transportation system reveals that it grew ever-more important within the German war economy. Integral to the German economy from the war's beginning, its importance grew due to German wartime adaptations. Despite this growth of importance, the U.S. and Allies continued to assign it an ever-lower priority. This is attributable to Allied difficulties in collecting and analyzing the German transportation system, as well as operational considerations driving a higher prioritization of other target systems. This case study reveals relevant lessons for modern target system analysts and operational planners.

15. SUBJECT TERMS

World War II, Air Power, Targeting

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
UNCLASSIFIED					Chairman, MAWS Dept
a. REPORT UNCL	b. ABSTRACT UNCLASSIFIED	c. THIS PAGE UNCLASSIFIED		27	19b. TELEPHONE NUMBER *(include area code)* 516-384-9580

Standard Form 298 (Rev. 8-98)

NAVAL WAR COLLEGE

Newport, R.I.

Air Power's Missed Opportunity: The German Transportation System

by

Patrick W. McMorrow

A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

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Signature:

27 April 2018

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Abstract

U.S. and Allied bombing of Germany during World War II affords an invaluable case study in target systems analysis. An examination of the German transportation system reveals that it grew ever-more important within the German war economy. Integral to the German economy from the war's beginning, its importance grew due to German wartime adaptations. Despite this growth of importance, the U.S. and Allies continued to assign it an ever-lower priority. This is attributable to Allied difficulties in collecting and analyzing the German transportation system, as well as operational considerations driving a higher prioritization of other target systems. This case study reveals relevant lessons for modern target system analysts and operational planners.

Introduction. Air Power's Missed Opportunity: The German Transportation System

During World War II (WWII), the United States devoted 35% of war production to air power, lost 80,000 airmen and 18,000 aircraft in the European Theater of Operations, and dropped millions of tons of munitions on Germany.[1] These efforts targeted Germany's war economy and fielded forces, which were categorized by U.S. analysts and planners into individual target systems. This effort's size and scale offers a case study in lessons for current target system analysts and operational planners, by determining whether U.S. Air Force targeting against Germany was consistent with modern target system analysis doctrine.

This case study reveals that while Germany's transportation system grew in importance to their war economy, U.S. planners assigned it an ever-lower priority. German wartime adaptations increased their transportation system's importance and the demands that other systems' interactions placed upon it. U.S. analysts and planners did not recognize these shifts, and instead prioritized it ever lower. Figure 1 synthesizes these shifts in importance and prioritization. The transportation system merited a higher targeting priority by Allied air planners, which reveals lessons for modern planners conducting and using target system analysis.

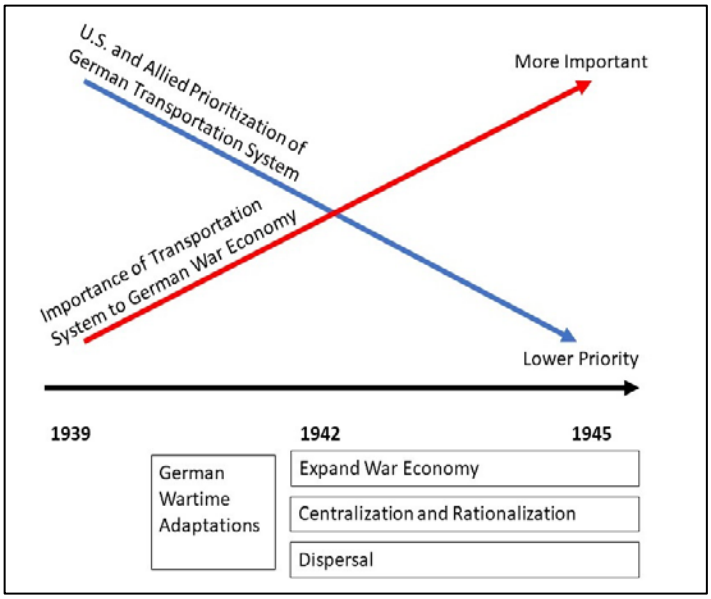

Figure 1. System importance - prioritization mismatch. As Germany's transportation system's importance increased, while the U.S. and Allies prioritized it lower. Source: Author.

[1] *The United States Strategic Bombing Survey: Summary Report (European War)*. Washington, D.C.: U.S. Government Printing Office, 1945, 5-6.

Theoretical Underpinnings and Background

Systems analysis underpins modern joint targeting doctrine, relying upon reductionist logic to categorize adversaries into systems which can be measured and described by components and entities within those components.[2] *Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3370.01B Target Development Standards* sets the joint standard for target system analysis, defining 15 target systems into which adversaries can generally be categorized. One is "Lines of Communication (LOC)/Transportation", the modern categorization of what WWII's planners referred to as the German "transportation system".[3]

CJSCI 3370 defines target systems as "typically a broad set of interrelated, functionally associated components and linkages that produce a common output or have a shared task or mission." Figure 1 is extracted from this document, and places target systems within the broader targeting taxonomy. A system example is "LOC/Transportation", whose mission is the movement of goods and services across a set of domains. Its broad set of "interrelated components" may include rail transport, water transport, air transport, power sources, command and control, repair facilities, etc. These components then include individual "targets" and "target elements", which are the levels where analysts develop individual facilities or similar entities for kinetic or non-kinetic targeting. The intent of target system analysis is to identify and analyze those components, their relationships, and critical nodes whose destruction or degradation would have the greatest payoff in meeting the

[2] Milan N. Vego, "Systems Versus Classical Approach to Warfare", *Joint Force Quarterly*, issue 52, 1st Quarter 2009, 41-43, 46.
[3] The Joint Staff, *Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3370.01B Target Development Standards*, May 2016, C-A-1.

commander's intent. As a "process and product", this analysis is not static, but is intended to be reactive and update for adversary adaptations.[4]

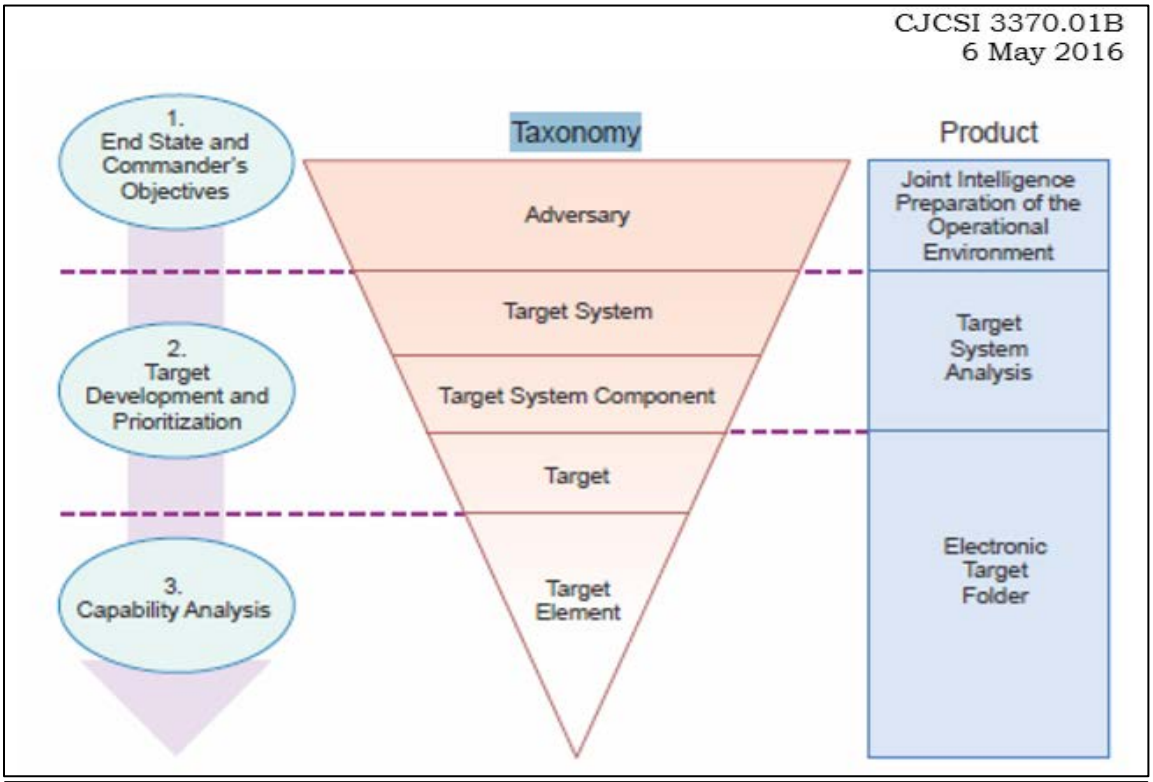

Figure 2. Graphical depiction of targeting taxonomy and analytical levels.
Source: *CJSCI 3370.01B Target Development Standards,* 6 May 2016, Figure 2, B-8.

CJCSI 3370 assigns target system analysis to Unified Commands, with potential delegation to joint components or service analytical centers. They are key operational-level tools through which joint and component staffs translate commander's intent and objectives into targeting methodologies. Table 1 lists the current CJCSI 3370's 15 "commonly used" target systems for nation-state actors, which govern joint force target development.[5]

During the interwar years, the United States Army Air Corps {later the Army Air Forces (AAF)} developed a theory of the enemy resembling modern target systems analysis.

[4] Ibid, A-1; C-1 - C-6.
[5] Ibid, C-A-1 - 2.

The Air Corps Tactical School's (ACTS) cadre, many of whom would go on to be WWII's planners and leaders, categorized the adversary's economic and warfighting capabilities into transportation, steel, iron, oil, munition sources, electric power, etc. This pre-war view held that *"the interruption of this closely-knit web by destroying one or more of its threads was considered the primary objective for an air force."*[6]

Table 1. *CJCSI 3370.01B*: The 15 target systems commonly used for nation-states		
1. Air Defense Forces	6. Ground Forces and Facilities	11. Special Operations Forces
2. Air Forces and Airfields	7. Industry	12. Transportation/Lines of Communication
3. Ballistic Missile Forces	8. Naval Forces and Ports	13. Weapons of Mass Destruction
4. Command, Control, Communications, Computers and Intelligence (C4I)	9. Petroleum Industry (POL)	14. Cyber Forces
5. Electric Power	10. Space Forces	15. Special Category
Source: *CJCSI 3370.01B*, 6 May 2016, C-A-1-2.		

The industrial web theory espoused by ACTS underpinned the U.S. strategic air campaign against Germany during WWII.* This theory viewed targeting as *"a campaign of selective targeting based on a careful analysis of the enemy's economic structure."*[7] ACTS reduced an adversary's war economy into "threads in the complex fabric of industrial economies, which they believed could be identified and assessed well in advance of hostilities."[8] The first U.S. plans which targeted Germany via air power reflect this view. Late 1941's Air War Plans Division-1 (AWPD-1) planning document used the term "target

[6] Robert T. Finney, *History of the Air Corps Tactical School, 1920-1940* (Alabama: Air University, 1998), 65-66; Haywood S. Hansell, *The Air Plan that Defeated Hitler* (Atlanta, 1972), 47.

* Whether this effort was truly "strategic" or a "campaign" remains the subject of considerable debate. That is outside the scope of this analysis.

[7] Tami Davis Biddle, *Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas about Strategic Bombing, 1914-1945* (New Jersey: Princeton University Press, 2002), 160.

[8] Ibid, 163.

system."[9] Whether termed "target systems" or "threads", the key concept remained the reductionist logic of dividing an adversary into measurable parts, with a view of affecting these parts via firepower.[10] AWPD-1 ranked the German transportation system as the second priority. By the war's end, it had steadily shifted lower in prioritization.[11]

The Importance of Transportation to the German Economy

U.S. and Allied planners misunderstood the German transportation system's importance to the German war economy, resulting in a low prioritization. In particular, German's electric power system interacted with the transportation system in a complex manner. By relying upon timely and sufficient coal delivery to regional power plants, the transportation system functioned as a critical component of the electric power system. As the wartime demand for power increased, so did this complexity. Initial U.S. estimates did not identify this interaction, and despite wartime improvements in intelligence, surveillance and reconnaissance (ISR), nor did wartime updates. The availability of electric power underpinned the ability of German industrial systems to produce the means of warfare.

Pre-war factors influenced wartime demands on the German transportation system. Regional specialization characterized German industry as it emerged from the pre-unification period of the mid-19th Century. At war's onset, coal was the "decisive factor" within this industrial geography.[12] The electrical power industry, and in turn recipient consumers, were

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[9] James Lea Cate, "Plans, Policies, and Organization," in *Plans and Early Operations: January 1939 - August 1942*, Vol 1 of *The Army Air Forces in World War II*, ed. James Lea Cate and Wesley Frank Craven (Chicago: The University Press of Chicago, 1948), 599.
[10] Vego, "Systems Versus Classical Approach to Warfare," 41.
[11] John E. Fagg, "Autumn Assault on Germany", in *Argument to V-E Day January 1944 - May 1945*, Vol 3 of *The Army Air Forces in World War II*, ed. James Lea Cate and Wesley Frank Craven (Chicago: The University Press of Chicago, 1951), 640, 649-647; Hansell, *The Air Plan that Defeated Hitler*, 163.
[12] Alfred C. Mierzejewski, *The Collapse of the German War Economy, 1944-1945: Allied Airpower and the German National Railway* (Chapel Hill: North Carolina, 1988), 22-24.

utterly reliant upon coal. Table 2 outlines German's electric power sources, with coal generating approximately 80% of their wartime electric power.[13]

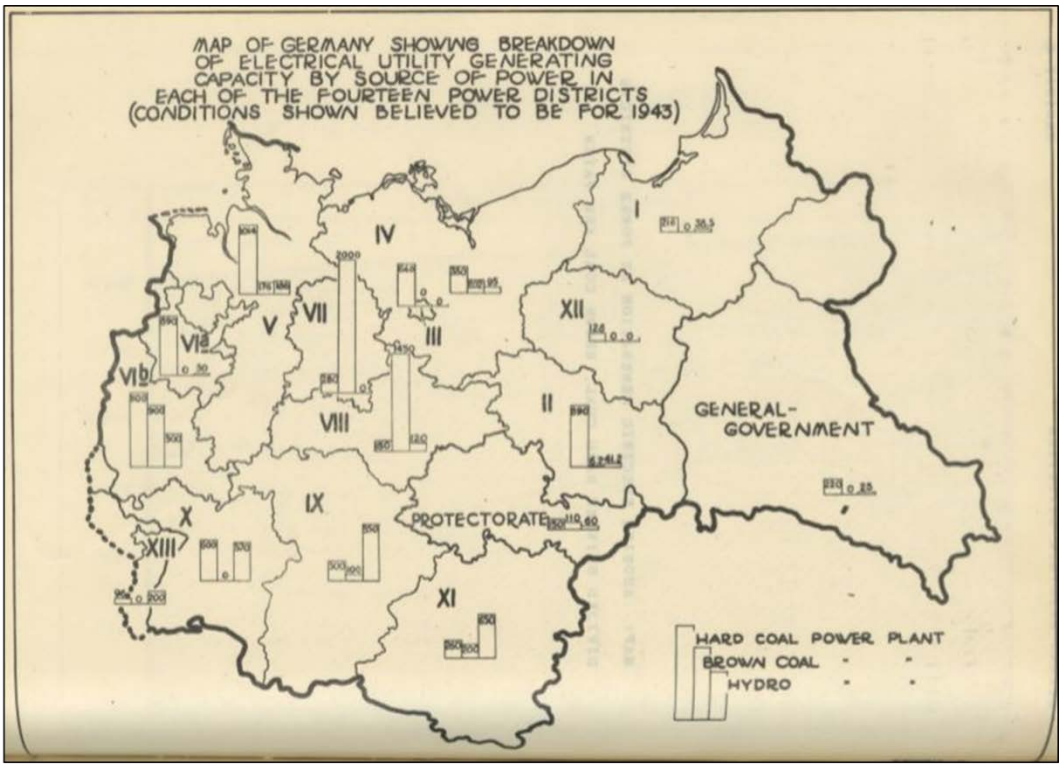
Table 2. Wartime Germany's Electric Power Production	
Source	Percentage Share
Hard Coal	46%
Brown Coal	33%
Water (Hydro) Power	21%
Source: *USSBS Report 205, German Electric Utilities Report,* 6.	

The transport of centrally-produced coal to geographically-separated electric power production characterized this industry. The primary sources of coal were the Ruhr Valley and Upper Silesia.[14] Germany was divided into individual industrial districts, each of which relied primarily upon regional electric power sources. To fire these plants, coal required transport from mines and processing areas (Ruhr and Silesia) to regional power plants. Figure 2 provides a graphical depiction of regional power generation of coal. Twelve of fourteen regional power areas relied upon coal to shoulder the electricity generation burden, enabling industrial assembly lines' output of Germany's means of war, ranging from aircraft to tanks, etc. Within the electric power system, the railway component was especially important, accounting for 90% of coal transport.[15]

As early as June 1942, leaders of the German Coal and Iron Associations sounded the alarm that insufficient rail transportation had caused the loss of 60 million tons of coal in 1941, and foresaw the potential loss of 2 million tons of iron in 1942 due to limited coal for blast furnaces and electric tools.[16] Demands placed upon transportation as a component of the electric power system were already challenging sufficiency. These insufficiencies

[13] *Records of the United State Strategic Bombing Survey (USSBS): Report 205, German Electric Utilities Industry Report*, (Washington, D.C.: U.S. Government Printing Office, 1947), 6.
[14] Mierzejewski, *The Collapse of the German War Economy*, 22.
[15] Ibid, 36.
[16] Ibid, 35.

reached German leadership in Berlin, where senior leaders identified the "question of transportation" as the key ingredient for sufficient power generation in southwestern



-Figure 3. German regional electric utility generation by power source.
-Source: *USSBS: Report 205, German Electric Utilities Industry Report, Exhibit C.*

Germany..[17]

This industrial geography, requiring distant coal for local electric power and industry, characterized the German war economy. Systems separate from the transportation system relied upon it as a critical component of their function. In the words of one historian, *"distributing coal in sufficient quantity, reliably, and in a timely fashion both to users in heavy industry near the mines and to consumers at the end of the production process far removed from them, depended upon the smooth functioning of the transportation system."*.[18]

[17] *Records of the USSBS: Report 205, German Electric Utilities Industry Report*, B-1 - B-31.
[18] Mierzejewski, *The Collapse of the German War Economy*, 35.

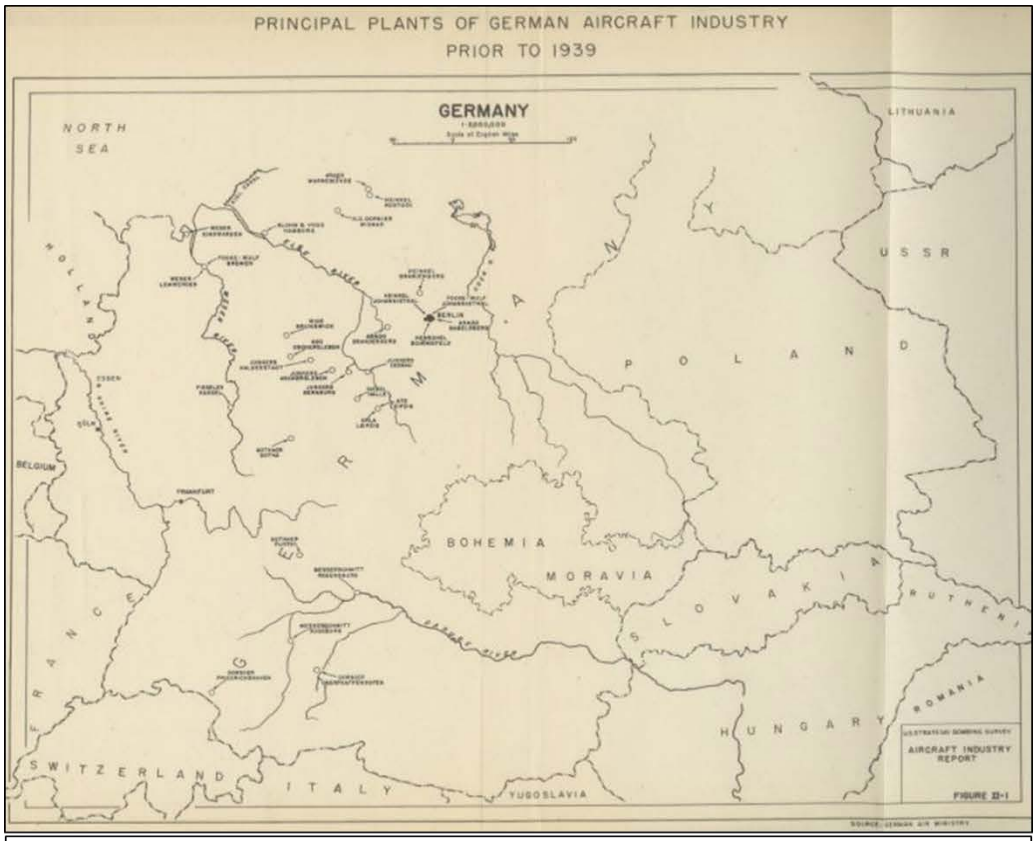
German Wartime Adaptation: Stressing the Transportation System

German adaptation to the wartime environment increased the demands placed upon the transportation system. Recognizing the unlimited war in which they were engaged, German leadership fully mobilized to a war economy beginning 1942. Adaptations included the centralization and rationalization of the war economy that year, and the subsequent dispersal of German production capacity. These adaptations increased the demands placed upon the German transportation system. Illustrating this reliance was its interaction with Germany's aircraft industry as a critical component of that system.

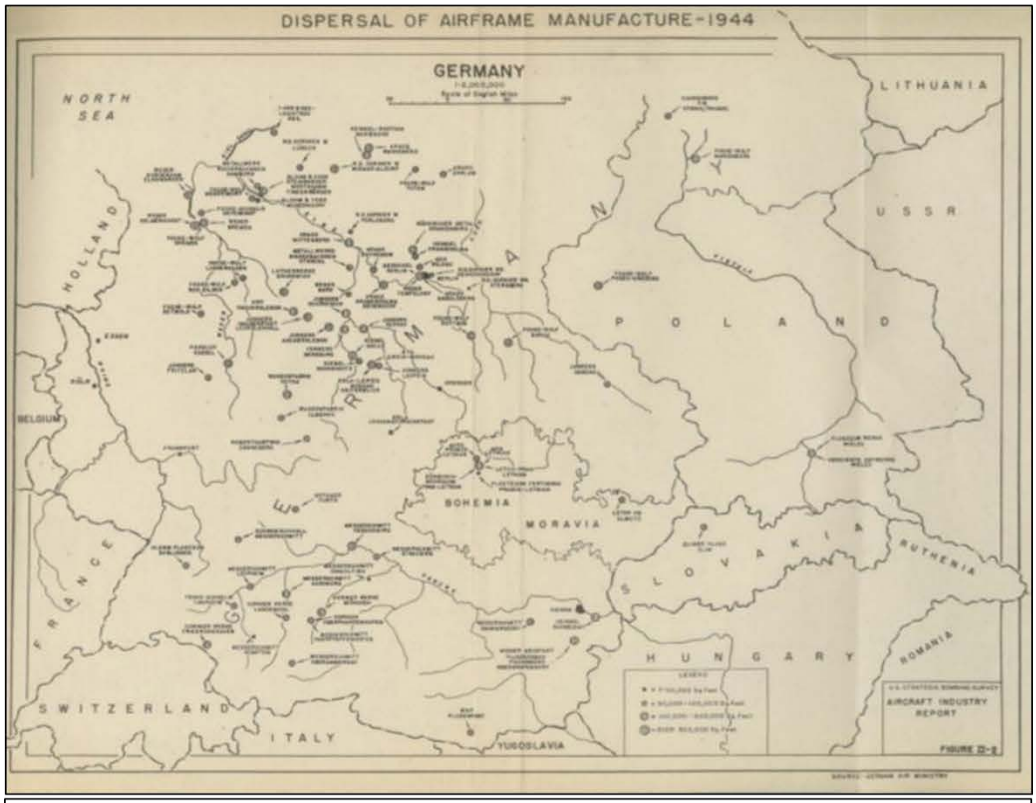
Mobilizing to meet wartime demands, Germany built new aircraft factories and dispersed them geographically, while centralizing resource distribution and rationalizing processes within the production chain. This expansion saw German aircraft industry grow from approximately 20 primary factories centered in Northern Germany to over 50 arrayed across both Germany and the occupied territories in the Czech Republic and Austria. Figure 3 depicts principal German aircraft production centers in 1939. Figure 4 reflects the growth and expanded geography of over 50 production centers in 1944. The centralization of this industry required timely and sufficient transport of scarce materials across a larger and more geographically-dispersed industrial system covering all of Germany and occupied Europe.[19]

German rationalization sought to increase production efficiency at the micro-economic level by minimizing waste at plants.[20] Prior to 1942's adaptation, individual factories were left to stockpile component parts on unused floorspace. 1942-1944's

[19] Richard J. Overy, *War and Economy in the Third Reich* (Oxford: Clarendon Press, 1994), 360-362.
[20] Ibid, 362.



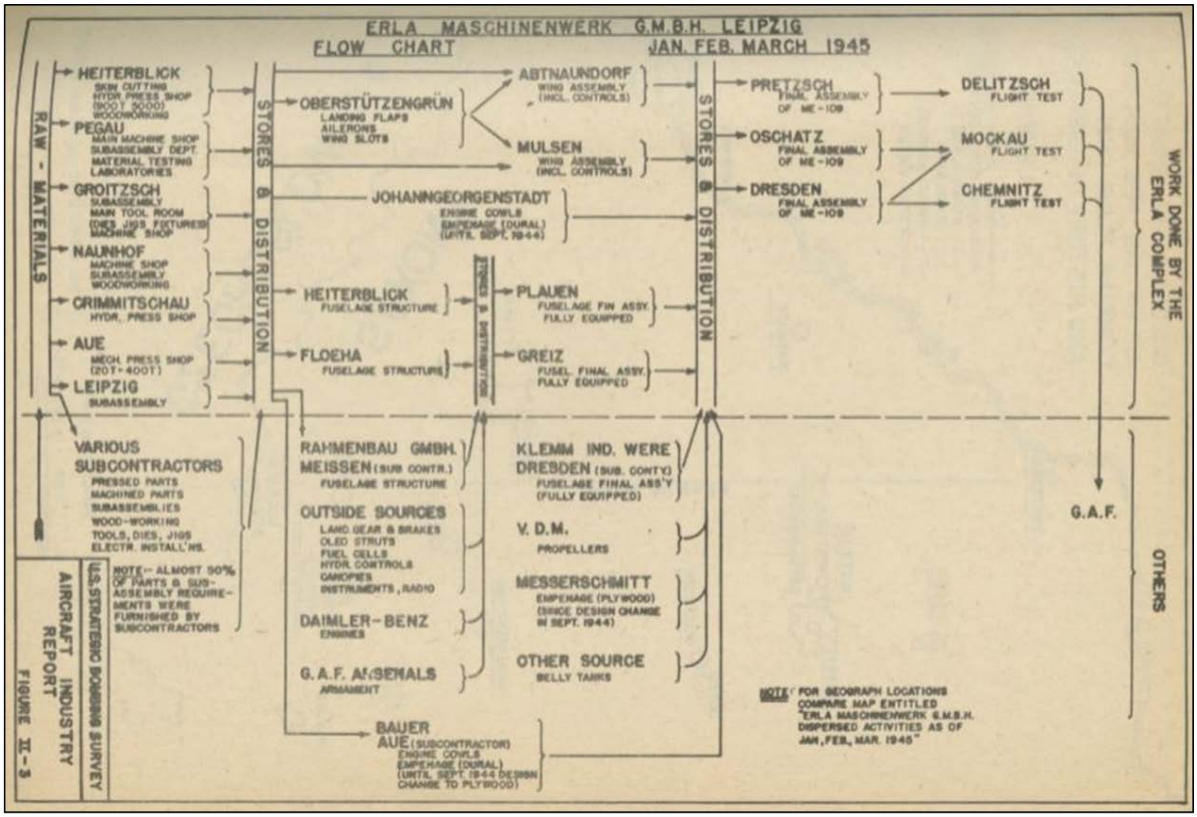
-Figure 4. Map showing German aircraft industry "principal plants" circa 1939.
-Source: *Records of the USSBS: Report 4, German Aircraft Industry Report,* Figure II-1.



-Figure 5. Map showing German aircraft industry dispersal circa 1944.
-Source: *Records of the USSBS: Report 4, German Aircraft Industry Report,* Figure II-2.

rationalization ensured this floorspace was used for production, and component parts arrived only at a scheduled point in the production process. Having sufficient component parts on hand enabled an elasticity of supply, enabling factories to overcome interruptions in the transport of components parts by utilizing those already on hand.[21] With no components available, factories relied upon the transportation system's ability to deliver the specific amount of component types at specific times, across a broader geographic area.

The experience of Germany's Erla aircraft manufacturing company illustrates this growing reliance upon centrally-managed transportation for component delivery across an expansive geography and is representative of the industry as a whole. Figure 5 is a contemporaneous process diagram of Erla's production chain. The diagram's named



-Figure 6. Process diagram of Erla Machinenwerk cicra Jan-Mar, 1945.
-Source: *Records of the USSBS: Report 4, German Aircraft Industry Report,* Figure II-3.

[21] Mierzejewski, *The Collapse of the German War Economy*, xiv.

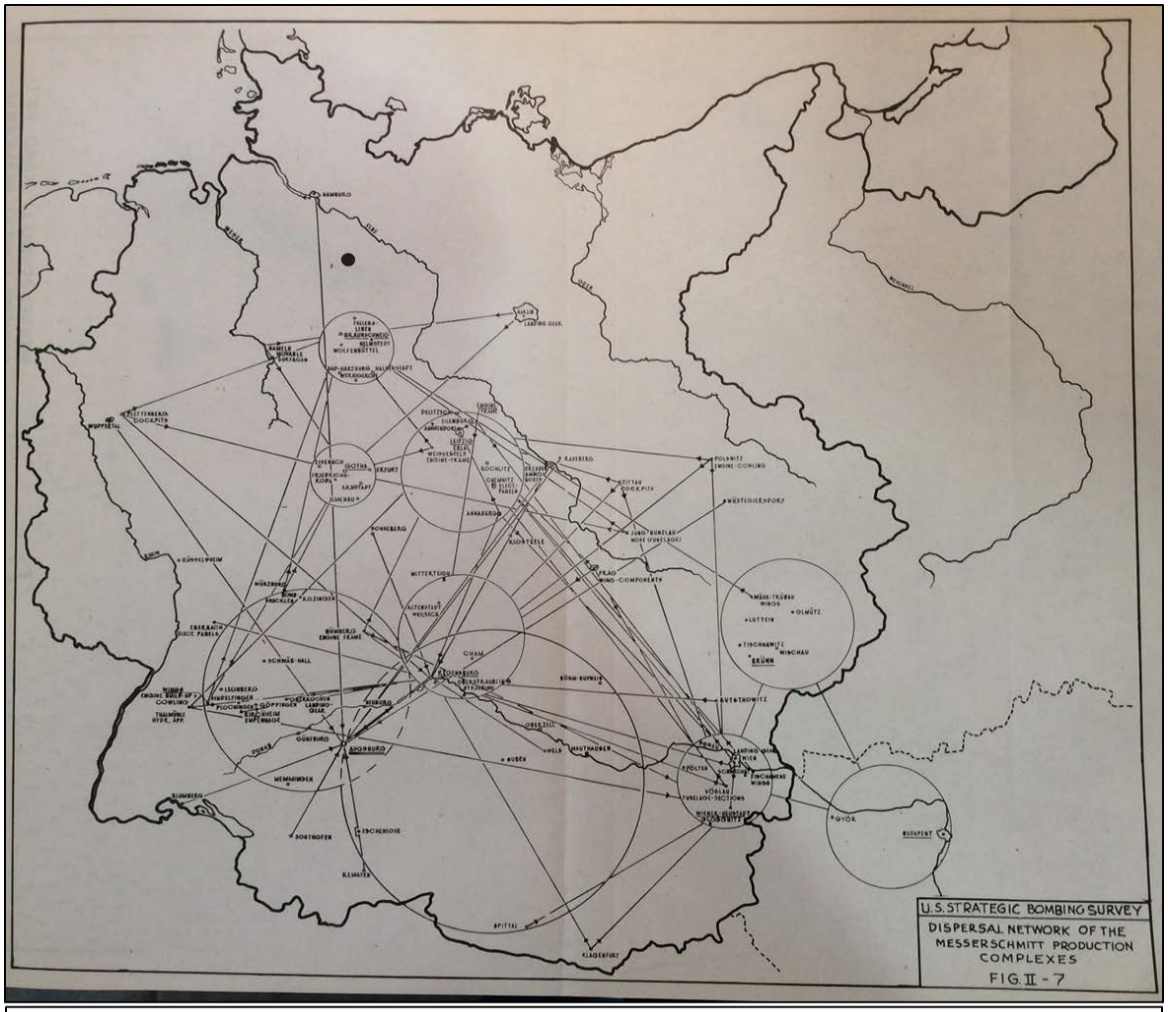
geographical locations span an area of Eastern Germany measuring approximately 100 miles by 100 miles. As Erla's factories complete individual aircraft components, they move left-to-right on the diagram as annotated by the 'Stores and Distribution' blocks. Ultimately, they are mated at the final assembly areas around Dresden for German Air Force (GAF) acceptance. Also annotated in the lower left corner is the fact that *"almost 50% of parts and sub-assembly requirements were furnished by subcontractors."* These subcontractors may be outside the depicted geography.

The transportation system underpinned this process, functioning as a critical component of aircraft production. It transported aircraft components within the 10,000 square miles containing Erla's facilities, plus the "*almost 50%"* of subcontracted subcomponents not accounted for within this geography. The *"raw materials"* on the left required transportation to factories, as did coal from which the machine tools drew power from the regional electric grid. As the Germans adapted to centralized control of these resources, and as rationalization drove down stockpiles of raw materials and component parts, the disruption of transportation prevented this industrial system from accomplishing its main task: Aircraft production.

Germany adapted to Allied air strikes by dispersing their war production capacity in an effort to make it more difficult to target, while building cushion and resiliency into production when it was successfully targeted. Between 1942 and 1944, the aircraft industry overall shifted from a concentration of 27 production centers to 729 smaller plants.[22] Figure 6 depicts the Messerschmitt Company's purposeful shift from their central production center at Augsburg to a network of over 50 smaller factories concentrated in nine regions (regions

[22] *Records of the USSBS: Report 4, German Aircraft Industry Report*, 24.

are depicted by circles). Approximately 200 miles separated Messerschmitt's southern and northern production areas. The transportation of raw materials, components and subcomponents throughout the network was analogous to the Erla plant. Germany's dispersal of these facilities increased the reliance of aircraft production on transportation.



-Figure 7. Dispersal network of the Messerschmidt production complexes, 1944-45.
-Source: *Records of the USSBS: Report 4, German Aircraft Industry Report,* Figure II-7.

This dispersal and reliance upon transportation applied to the broader German war economy. Post-war U.S. analysts noted that Dusseldorf's Rheinmetall-Borsig plant's single gun machining center dispersed to 24 individual sites across both Germany and German-occupied Poland. While the threat of bombing prompted German dispersal, it was the

disruption of the transportation component which disrupted output, as the system could not transport raw materials and components between individual smaller facilities.[23] Ultimately, they identified the transportation system's disruption as the most important component in decreasing ordnance output, even greater than direct bombing attacks on ordnance plants.[24]

Allied Analysis and Decisions: Missed Transportation's Importance

The German transportation system's interaction within the German war economy presented a difficult problem set for U.S. and Allied Intelligence, Surveillance and Reconnaissance (ISR). Intelligence personnel struggled to analyze an economy organized differently than their own, while the transportation system's nature complicated collection efforts. While German wartime adaptations made the transportation system ever-more important, these ISR challenges combined with operational considerations prompted U.S. and Allied air planners to assign the transportation system an ever-lower priority.

At the war's onset, information available to Allied planners varied in quality. For instance, in order to gather information on Germany's electric grid, planners and intelligence personnel linked with New York-based financiers of pre-war German building projects. This resulted in high fidelity data on those specific components and entities.[25] However, this data only supported analysis of the power distribution component and not the sources of electric power. As the official AAF historians note, the underlying intelligence supporting individual

[23] *Records of the USSBS: Report 101, Ordnance Industry Report,* 22-25.
[24] Ibid, 37-38; for additional discussion see *Records of the USSBS: Report 4, German Aircraft Industry*, 7.
[25] Hansell, *The Air Plan that Defeated Hitler,* 51.

assessments of 19 German war-making industries was often based on projecting information associated with American systems onto German systems, resulting in mirror imaging.[26]

Some assessments claimed to correctly note the transportation system's importance within Germany's war economy. In his postwar memoirs, AWPD-1's main architect explicitly noted its importance to both the geographically-dispersed production economy as well as within individual production chains.[27] However, it is worth considering that these memoirs were written in hindsight, and with the benefit of the post-war U.S. Strategic Bombing Survey (USSBS) data. While 1941's AWPD-1 did prioritize transportation for attack, it is worth noting that neither it - nor the architect's memoirs - synthesize the interaction of the transportation and electric power systems, and the latter's reliance upon the former as a critical component. Only as late as the 1980s did scholars with greater access to German records fully explore this relationship.[28] However, even in the war's immediate aftermath, observers recognized the faults of U.S. and Allied analysts and targeteers.

Some historians contend that the U.S. plans of 1941-42 accurately assessed the importance of Germany's centralized rail network, whereas 1943's plans were based on a false picture of the German rail network.[29] Historians of U.S. wartime intelligence synthesized these wartime judgments with the postwar data, primarily from the USSBS. In commenting on the intelligence underpinning of these plans, they note:

[26] Arthur B. Ferguson, "The CBO Plan," in *Torch to Pointblank, August 1942- December 1943,* Vol 2 of *The Army Air Forces in World War II*, ed. Wesley Frank Craven and James Lea Cate (Chicago: The University Press of Chicago, 1949), 354-355.
[27] Hansell, *The Air Plan that Defeated Hitler*, 81-82.
[28] Mierzejewski, *The Collapse of the German War Economy*, xi-xv.
[29] Ibid, 78.

> *"The prevailing interpretation of the German economy as already strained to the breaking point and incapable of further expansion - and the inability to foresee the steps a nation engaged in a total war might take to continue that struggle - is at least implicit throughout. In addressing transportation, for example, planners concluded that this "vital link" was "at present taxed to its maximum capacity." Within six months, several more complete analyses of the German rail system would indicate that some 30 percent of the traffic it carried was "not essential" to the war effort."*[30]

The above passage illustrates several contributing factors to Allied intelligence misunderstanding the German transportation system. First, they projected Allied practices onto German industry by assuming that the transportation system was operating at full capacity, potentially missing clues that otherwise took months to unravel.[31] This resulted in Allied planners not appreciating that 30% of transportation capacity which Germany shifted from "not essential" to essential wartime tasks, cushioning the demands on transportation. Second, Allied analysts did not anticipate German economic expansion to support a now-unlimited war effort.[32] For instance, they missed Germany's creation of a Central Planning Department within the 1942 wartime adaptation.[33] Third, Allied analysts over-emphasized locomotive production as the key target system component representative of the overall target system. This blinded analysts to impacts on the target system attributable to attacks on

[30] Robert C. Ehrhart, Thomas A. Fabyanic and Robert F. Futrell, "Building an Air Intelligence Organization and the European Theater," in *Piercing the Fog: Intelligence and Army Air Forces Operations in World War II*, ed. John F. Kreis (Washington, D.C.: Air Force and Museums Program, 1996), 151.
[31] Mierzejewski, *The Collapse of the German War Economy*, 77.
[32] Richard J. Overy, *The Air War 1939-1945*, Virginia: Potomac Books, 2005, 123.
[33] Mierzejewski, *The Collapse of the German War Economy*, 76-77.

other components such as LOCs, chokepoints, bridges, marshalling yards, and repair shops.[34] Surveillance and reconnaissance challenges exacerbated these analytical problems.

The transportation system presented challenges to U.S. and Allied collection capabilities. Planners primarily relied on photo reconnaissance to reveal damage to target systems and their components. Investing heavily in this capability enabled reasonably accurate data collection within operational constraints that included range, weather, enemy defenses and targets that could be photographed. Within these constraints, photos could reveal the status of transportation components such as marshalling yards; however, they could not quantify any throughput information. That data required lower-density collection such as signals intelligence, human intelligence, or document exploitation.[35] As the war progressed, Allied intelligence generally got better, particularly for post-strike recon with techniques to collect and correlate signals and imagery intelligence.[36] Despite such advances, planners relied upon extrapolation from collection in similar target areas, drawing inaccurate conclusions regarding overall target system behavior.[37] Insight into Germany's war economy required lower-density collection, such as documents captured in Paris, August 1944.

These specific documents' capture and exploitation afforded the Allies their most granular insight into the interactive effects of the German transportation system's degradation. They documented French national railway traffic flow in May 1940-May 1944, and clearly showed drops in coal shipments and commensurate drops in electric power.[38]

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[34] *Records of the USSBS: Report 203, German Locomotive Industry Report*, 30-31.
[35] Mierzejewski, *The Collapse of the German War Economy*, 98-100.
[36] Alexander S. Cochran, Robert C. Ehrhart and John F. Kreis, "The Tools of Air Intelligence: ULTRA, MAGIC, Photographic Assessment, and the Y-Service," in *Piercing the Fog*, ed. John F. Kreis, 77.
[37] Mierzejewski, *The Collapse of the German War Economy*, 164-165; *USSBS: Report 4, Aircraft Industry Report*, 8.
[38] Mierzejewski, *The Collapse of the German War Economy*, 100.

Allied intelligence personnel were thus able to analyze this finding and extrapolate similar effects within the German electric power and coal-driven industrial systems.

Five wartime documents express U.S. and Allied prioritization of German target systems. Table 3 synthesizes these shifting priorities. The previously-discussed AWPD-1 was updated as AWPD-42 in late 1942. The Committee of Operations Analysts (COA) and Combined Bomber Offensive (CBO) documents are the third and fourth, respectively. Based on the POINTBLANK directive, the COA's civilian analysts produced a March 1943 prioritization whose intent was to collapse Germany's economy in the shortest possible time. These were partially accepted for incorporation into the Combined Bomber Offensive (CBO) plan of late 1943. The final document is September 1944's Combined Chiefs of Staff (CCS) directive. This set target priorities, with specific annotations for the enemy's transportation and air forces target systems, whose prioritizations shifted with circumstances.

Allied planners ultimately prioritized the transportation system ever-lower. Retaining GAF and aircraft industry as the top priority is attributable to the intermediate objective of air superiority over mainland Europe. However, the shift in transportation from the number two priority in 1941-42 to lower (at times, not even in top seven) as the war progressed contrasts with its importance to the German war economy.

Operational considerations outside of these target systems' relative importance likely impacted this prioritization. Submarine construction yards assumed the second priority beginning Aug 1942, and the CBO retained it a year later, ultimately trumping the COA

Table 3. Allied prioritization of German target systems during WWII					
Priority	AWPD-1 (Aug 41)	AWPD-42 (Aug 42)	COA (Mar 43)	CBO (Oct 43)*	CCS Dir. (Sep 44)
1	German Air Force and Aircraft Industry	German Air Force and Aircraft Industry	Single Engine Fighter Aircraft Production	German Air Force and Aircraft Industry	Oil
2	Transportation	Submarine Building Yards	Ball Bearings	Submarine Construction Yards and Bases	Ordnance Depots, Motorized Vehicle plants
3	Electric Power	Transportation	Petroleum Products	Ball Bearings	Transportation**
4	Petroleum	Electric Power	Grinding wheels and abrasives	Oil	German Air Force**
5	Morale	Petroleum	Nonferrous metals	Synthetic Rubber and Tires	
6			Rubber products	Military Transport Vehicles	
7			Submarine Construction Yards and Bases		

Sources: AWPD-1, AWPD-42 and CBO extracted from Hansell, *The Air Plan that Defeated Hitler* 163; COA extracted from Ehrhart et al, "Building", *Piercing the Fog*, 154; CBO extracted from Fagg, "Autumn Assault on Germany", in Vol 2 of Craven and Cate; also see Craven & Cate in footnotes for discussion.[39, 40, 41]

*The CBO would be modified by Combined Chiefs of Staff Directive on 13 Feb 1944. This directive did not substantially alter the target priorities, but rather was intended to focus British RAF operations on specific target systems rather than area bombing, with the principle objective of establishing air superiority over the Germans.[42]

**These target systems were identified as "special categories" whose prioritization were subject to circumstances. See Fagg in Craven and Cate in footnotes for discussion.

[39] Also see: Cate, "Plans, Policies, and Organization," in *Plans and Early Operations*, Vol 1 of *The Army Air Forces in World War II*, ed. Cate and Craven, 599.

[40] Fagg, "Autumn Assault on Germany", in *Torch to Pointblank*, Vol 2 of *The Army Air Forces in World War II*, ed. Cate and Craven, 640, 649-647.

[41] Ehrhart, Fabyanic and Futrell, "Building an Air Intelligence Organization and the European Theater," in *Piercing the Fog*, ed. John F. Kreis, 154; Ferguson, "The CBO Plan," in *Torch to Pointblank*, Vol 2 of *The Army Air Forces in World War II*, ed. Cate and Craven, 356-365.

[42] Ferguson "Winter Bombing," in *Argument to V-E Day*, Vol 3 of *The Army Air Forces in World War II*, ed. Cate and Craven, 27-28.

recommendation to shift it lower. This is attributable to the requirement of degrading the German submarine threat to Allied shipping, with the Air Forces being but one component in the overall Allied war effort.[43, 44]

The COA's prioritization reflected an approach intended to precipitate Germany's collapse in the shortest possible time. Their prevailing view was that targeting the transportation system would require time to manifest decisive results.[45] In reality, German wartime adaptations made the opposite true. By expanding their economy to a full wartime footing, managing it centrally and with local rationalization, and dispersing their production centers, Germany relied ever more heavily on the transportation system.[*]

As one historian of the Allied air campaign notes, the pressure for immediate results colored commanders and staffs in their assessments of impacts to the German transportation system during the Oct-Nov 1944 period. Their primary measurement was whether sufficient German military forces transited the railways or backup transportation methods. This generally occurred, with the notable exception of the Cologne-Coblenz-Trier sector, which was transformed into a "railway desert" prior to Allied ground forces moving into that area. This same historian notes the drastic effects this assault on transportation actually had, manifesting itself in forms other than just 'vital military traffic'. It included impacts on coal shipments and the electric power industry, raw materials and subcomponents within other

[43] Ehrhart, Fabyanic and Futrell, "Building an Air Intelligence Organization and the European Theater," in *Piercing the Fog*, ed. John F. Kreis, 151.
[44] Samuel Eliot Morison, *History of United States Naval Operations in World War II, Vol IX Sicily-Salerno-Anzio, January 1943-June 1944*, Little Brown and Company, Boston: 1954, 5; Overy, *The Air War*, 74.
[45] Ehrhart, Fabyanic and Futrell, "Building an Air Intelligence Organization and the European Theater," in *Piercing the Fog*, ed. John F. Kreis, 155.
[*] Figures 4-5 demonstrate the expansion of Germany's aircraft industry. Figure 6 demonstrates one company's centrally-managed, rationalized and transportation-intensive production processes. Figure 7 demonstrates the dispersal of one company's production centers, which exacerbated the transportation stresses shown in Figure 6.

industries.[46] Even in late 1944, some within AAF leadership were hesitant to prioritize the German transportation system, citing concerns regarding its complexity and flexibility.[47]

Transportation Appropriately Prioritized?

Arguably, U.S. and Allied air planners appropriately prioritized the German transportation network prior to the Allied invasion of Normandy. During OVERLORD planning, Allied leadership selected the air planners' "transportation plan", and prioritized the German-controlled transportation system as the second priority behind the intermediate objective of air superiority.[48] The plan was characterized by *"attacks on the French and Belgian railway system as a means of inhibiting the movement of German supplies and soldiers in the Normandy region, thereby constraining the enemy's ability to reinforce the front and wage a war of maneuver."*[49] During the two months prior to the 6 June invasion, Allied planners targeted individual transportation system components, including locomotives, marshalling yards, switches and bridges.[50] Incorporation of British nighttime bomber operations resulted in 24 hour operations, adding railway centers as suitable night targets.[51]

The results were commensurately impressive, with daily German troop carrying capacity at less than 50% of pre-invasion requirements, and daytime movement essentially at a standstill.[52] *"Thanks to the bombing of communications and constant fighter-bomber*

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[46] Fagg, "Autumn Assault on Germany," in *Argument to V-E Day*, Vol 3 of *The Army Air Forces in World War II*, ed. Cate and Craven, 640, 655-657.
[47] Craven and Cate, foreword to *Argument to V-E Day*, Vol 3 of *The Army Air Forces in World War II*, ed. Cate and Craven, xv.
[48] Fagg, "Pre-Invasion Operations," in *Argument to V-E Day*, Vol 3 of *The Army Air Forces in World War II*, ed. Cate and Craven, 138.
[49] Biddle, *Rhetoric and Reality in Air Warfare*, 234.
[50] Fagg, "Plan for OVERLORD," in *Argument to V-E Day*, Vol 3 of *The Army Air Forces in World War II*, ed. Cate and Craven, 72-79.
[51] Biddle, *Rhetoric and Reality in Air Warfare*, 236.
[52] Claude Postel, "The Air Attacks on Communications 6 March to 6 June 1944", trans by *Military Review* from *Revue Historique de L'Armee*, 1-2, 1950, 74-77.

sweeps over the German rear areas, German daylight movement became hazardous, and was often impossible."[53] The "transportation plan" was a central component of softening German tactical defenses and their operational ability to reinforce across Northern France, thus enabling Allied forces to win the race to buildup combat power in Normandy.[54]

This argument holds that U.S. and Allied planners recognized the importance of transportation to German forces and their attempts at maneuver warfare. With the intent of isolating northern France, the transportation system was accorded de facto highest priority, behind air superiority, which had largely been established and would be held until war's end.

OVERLORD was one major operation whose target prioritization does not translate into theater-wide assessment and prioritization across the war's timeframe. The German transportation system was critical to troop movements and logistical support, the primary functions targeted by OVERLORD's "transportation plan". However, its complex interaction within the German economy went beyond one theater's battlefield support functions. U.S. and Allied assessment and prioritization of the transportation system continued to miss these interactions, whose complexity only increased with Germany's wartime adaptations.

Conclusions

As the war progressed, Germany's war economy increasingly relied upon its transportation system. Functioning as a critical target component of other systems, the transportation system merited a higher prioritization than it received. Germany's electric power system, and consequently much of their war-related industries, relied upon the timely

[53] Max Hastings, *Overlord: D-Day and the Battle for Normandy*, New York: Random House, 1984, 266.
[54] Ibid, 276.

and sufficient delivery of coal to regional power plants. As the economy expanded, so did the demand for power. As the aircraft industry expanded and dispersed, it relied upon its transportation component to deliver sufficient aircraft sub-components on time, or the production chain would halt. Beginning with an industrial geography dependent upon transportation, Germany's wartime adaptations increased their reliance upon that system.

In opposition to transportation's growing importance, U.S. and Allied planners prioritized this system ever lower. They assumed Germany's economy was organized and operating approximately the same as Allied economies, not recognizing the demands that German adaptations had placed upon the transportation system. Difficulties in collecting meaningful data on throughput requirements and outputs exacerbated this trend. Only after the war did U.S. analysts gain insight into the complex interaction which merited the transportation system considerably higher prioritization than it had received.

World War II's bombing campaign affords a rich case study in target system analysis. While consistent with the modern notions of categorizing an adversary into individual systems, U.S. and Allied analysts did not fully consider the complex interaction between German systems. As a critical component of other target systems, the German transportation system merited a higher priority. Despite the German transportation system's increasing importance, the Allies prioritized it ever-lower due to an inability to recognize and adapt to this shift. This conclusion reveals lessons relevant to analysts and planners today.

Operational Lessons Learned and Recommendations

The danger of projection bias. Absent intelligence data, Allied planners projected British and U.S. systems onto Germany; when intelligence data became available, those

planners fit it into those molds. Absent intelligence and information, planners must be cognizant of not projecting their own county's systems onto the adversary.

Good ISR does not equal perfect ISR. Despite wartime advances in ISR, U.S. and Allied intelligence personnel were unable to garner sufficient internal data on the German war economy. Such fog will always be present in wartime, and mere extrapolation of measurable data is likely insufficient to dispel such fog.

Complex system interaction. Targeting one system produces unpredictable effects in systems adjacent to the targeted system. The threat of bombing drove Germany to disperse their aircraft industry, whose complex interaction placed greater burdens on transportation.

Adaptation impacts system interaction. Adversary adaptation may change the complexity of system interaction, shifting the relative targeting priority for planners. In expanding to a full war economy in 1942, centralizing and rationalizing the economy, and dispersing production, Germany increased their reliance on the transportation system.

Commander's guidance matters. The Allies had greatly mitigated the German submarine threat by 1943. Despite difficulties in targeting submarine support infrastructure, Allied commanders insisted upon prioritizing this above transportation.

Importance of assessment mechanisms. Absent the ability to identify and track impacts within the transportation system, and within the German war economy overall, planners relied upon extrapolation and a series of culturally-biased errors. It is essential that planners have in place some mechanism to measure effects within a target system.

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